

Space Weather Technical Forecast

From the 24th of September, the way we distribute this forecast is changing and you will need to take action to continue receiving it. You should have received an email on the 4th of September explaining the steps required to do this. If you have already signed up to receive the forecast on our premium website, please disregard this message. If you haven't, or if you need help with the process, please contact moswoc@metoffice.gov.uk

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Further M-class flares likely with a slight chance of X-class flares. Chance of G1-G2 Minor to Moderate storms with CME arrivals possible on Day 1 (14 Sep) and Day 3 (16 Sep).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High activity with a peak flare M3.0 at 14/0741 UTC from AR3825 in the southeast, as well as numerous M-flares from this region and other regions at, or just over the western limb.

There are eight sunspot regions on the visible disc, including one unnumbered region in the south centre disc. AR3825 (Eac/Beta-Gamma-Delta) continued to rotate into clearer view and indicated notable magnetic complexity including at least one delta spot and significant magnetic looping on SDO/AIA171 imagery. A number of sunspots AR3813, AR3815 and AR3816 are approaching the southwestern limb and becoming increasingly foreshortened in coronagraph imagery. Generally though, these regions appear to be stable and in decay. Slight proliferation of intermediate spots was observed in AR3824 (Csi/Beta) near centre disc in the southern hemisphere. The remaining regions are generally small, with limited magnetic complexity and activity at this time.

A CME that was observed at, or close to the southwest limb, emerging around 14/0300 UTC is awaiting modelling to determine if there is any Earth-directed component. Numerous other CMEs were observed but these are not deemed to be Earth-directed.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as observed by ACE at L1, were indicative of the waning influence of the CME that arrived at Earth on 12 Sep. Solar wind speeds were quite erratic but reduced from 450-500 km/s to 370-420 km/s, along with predominantly below average density. The Interplanetary Magnetic Field (IMF) Bt, was Weak to Moderate, between 4-10nT, while the north-south component, Bz, remained largely negative, peaking -9nT between 13/1930-2130 UTC. Phi angle was largely positive (away from the Sun). The net result of these parameters was for mostly Unsettled to Active geomagnetic activity, but with a G2 Moderate storm interval between 13/0000-0300 UTC and a Quiet interval from 14/0600-0900 UTC.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was steady background levels. High energy electron flux (greater than 2MeV) observed by GOES16, generally varied on a diurnal cycle between background and Moderate levels, but briefly rose to High levels, peaking at 1140pfu at 13/1645 UTC. The associated 24-hour fluence showed a rising trend but remained below the Active threshold, with 1.77e7 integrated pfu observed at 14/0000UTC.

Four-Day Space Weather Forecast Summary

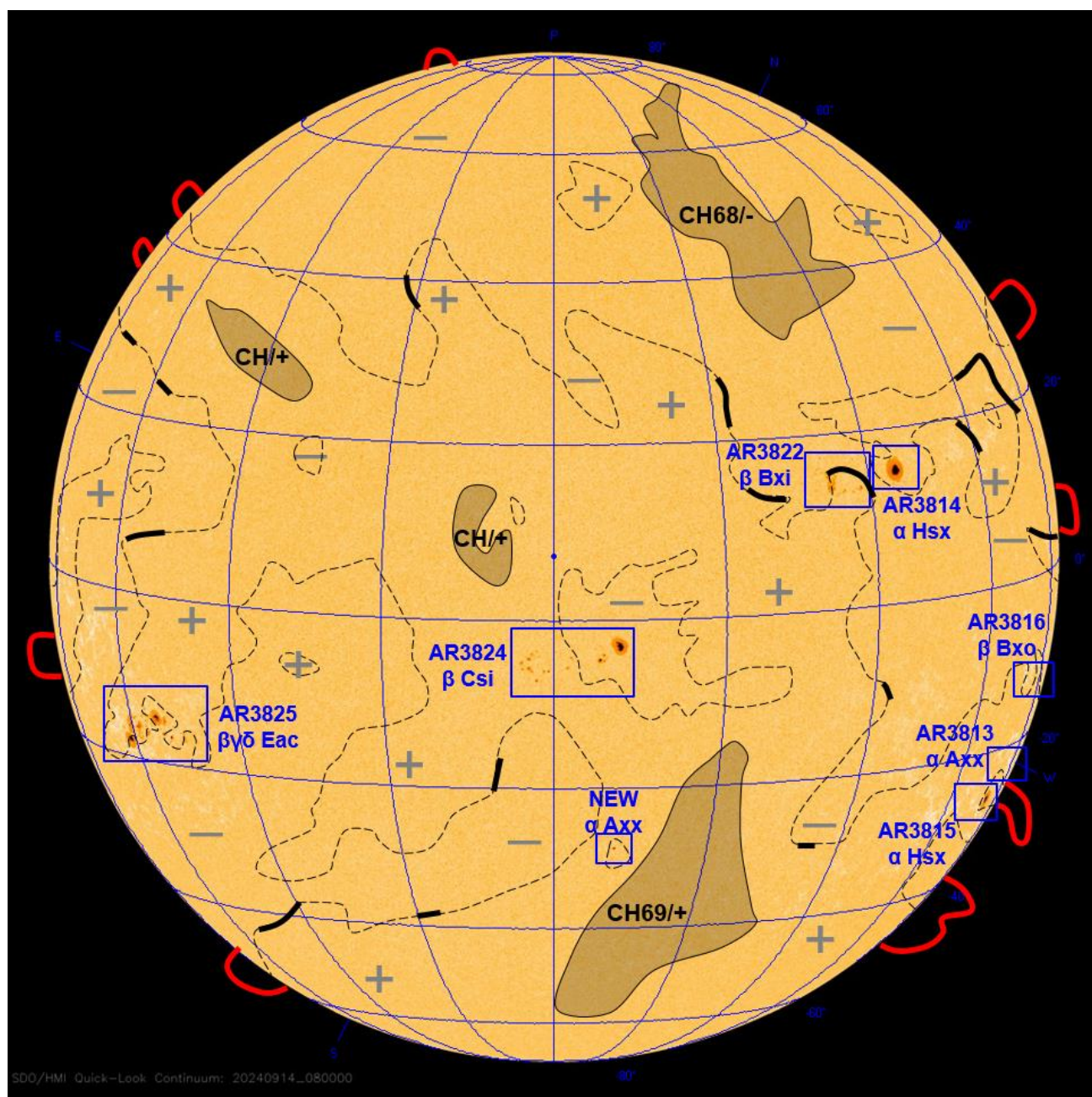
Solar Activity: Moderate to High activity is expected, with further M-flares likely, and a slight chance of X-class flares. These most likely from AR3825 in the southeast.

Solar Wind / Geomagnetic Activity: Solar winds are between slightly elevated and background levels following the CME arrival on 12 Sep. There are two further CME arrivals in the forecast - first one on Day 1 (14 Sep), although low confidence and yet to arrive. The second a potential glancing impact on Day 3 (16 Sep) - plus the potential onset of the high speed stream of CH68 and/or CH69 on Days 2 and 3 (15 and 16 Sep).

On Day 1 (14 Sep) geomagnetic activity is expected to be Quiet to Active, with a chance of peak G1 Minor Storm conditions should any CME impact from late 10 Sep CME occur. Mostly Quiet to Unsettled activity is expected by Day 2 (15 Sep), then generally Unsettled to Active conditions on Day 3 (16 Sep) with isolated G1 Minor Storm intervals possible. Activity should subside to Quiet and Unsettled levels by Day 4 (17 Sep).

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background levels. However current activity at or near the southwest limb gives a chance of proton flux rising, most likely on day 1-2 (14-15 Sep), with a slight chance of exceeding the S1 Minor Radiation storm level. This risk receding later in the period. High energy electron flux is expected to remain mainly at Background with the associated 24 hour fluence remaining below Active.

Figure 1. Solar Analysis Valid 14/0800 UTC.



Key: Filament — , Prominence — , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

The CME that arrived on 12 Sep resulted in disturbed geomagnetic conditions that are still ongoing with background to slightly elevated solar winds. A further CME arrival was forecast to arrive earlier on Day 1 (14 Sep) but has not yet been detected at L1 (at time of writing). This originated from the same sunspot as 12 Sep CME arrival, AR3814, from an M1.0 flare at 10/2350 UTC. This CME was slower and more diffuse however, suggesting a weaker arrival and carries low confidence.

Another CME was observed leaving the sun at around 13/0930 UTC, the result of a filament eruption, most likely associated with the M2.9 flare observed at 13/0835 UTC from AR3814. Its analysis revealed that the bulk of the ejecta is expected to pass ahead of Earth's orbit towards Stereo-A, however it may give a glancing blow on Day 3 (16 Sep).

A CME that was observed at, or close to the southwest limb, emerging around 14/0300 UTC is awaiting modelling to determine if there is any Earth-directed component. Numerous other CMEs were recently observed but these are not deemed to be Earth-directed.

Aside from these arrivals, there are also two coronal holes which may influence the forecast. CH68/- is the most westward of these, with any high speed stream likely connecting late on Day 2 (15 Sep), but is both quite far north and unfavoured for a significant connection at this time of year. CH69/+ is then most likely to connect on Day 3 (16 Sep). Confidence is low however, due to its southern location and Earth currently being above the solar equator in its orbit. The bulk of any fast wind from this feature may subsequently pass south of Earth, although MOSWOC Enlil which indicates strong solar winds (around 600km/s) on day 3 and 4 (16 and 17 Sep), meaning that this aspect of the forecast carries low confidence.

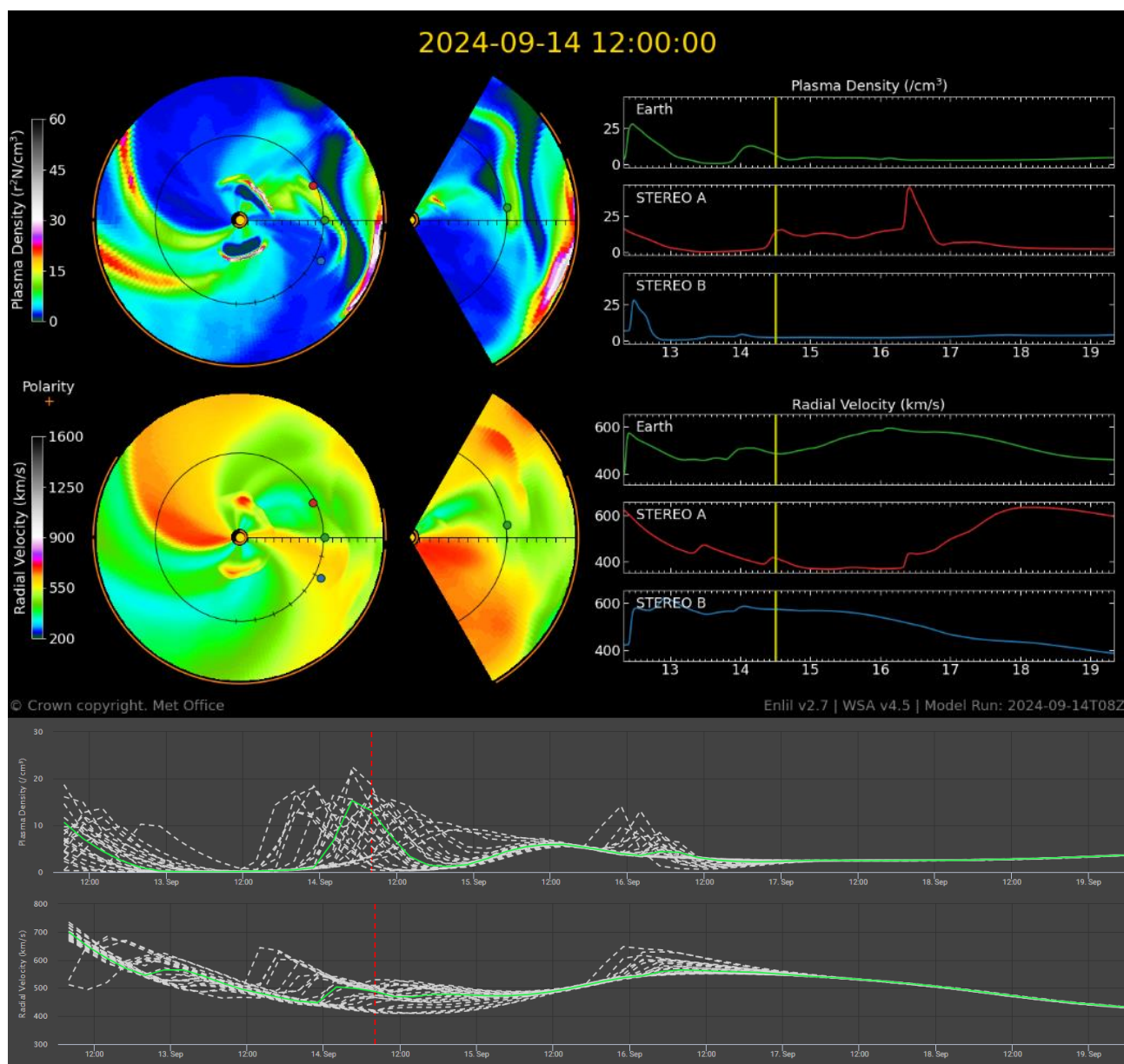
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Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	Yes	40	5	30	5
Strong	G3	No	5	1	5	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0657	Partial	M1.0 Flare AR3814	N30 E01	709 km/s	14/0500 UTC +/- 5 hrs	Weak, diffuse CME with low confidence arrival
13/0930 UTC	Partial	M2.9 Flare AR3814	NW Quadrant	667 km/s	16/0600 UTC +/- 6 hrs	Glancing impact

Figure 2: Enlil modelling and output for 14/1200 UTC with ensemble



Radio Blackouts - X-Ray Flares:

Moderate to High activity is expected, with further M-flares likely, and a slight chance of X-class flares.

There are eight sunspot regions on the disc with the most active being AR3825 in the southeast with a M3.0 flare observed at 14/0741 UTC. It is a compact and magnetically complex region, containing at least one delta spot and has previously been the source of an X1.3 flare on 12 Sep. It may reveal more magnetic complexity as it rotates into clearer view on the visible disc. AR3814 in the northwest has decayed to a mature unipolar group as the spots surrounding the main leader have faded. A new, small unipolar region has formed in the south centre disc. The remaining regions are generally small, with limited magnetic complexity and activity at this time.

AR3813, AR3815, AR3816 are due to rotate off the visible disc by Day 3 (16 Sep), meanwhile returning regions Ex-AR3798, AR3799 and AR3800 are due back over the eastern horizon in the next couple of days. Far-sided helio-seismic soundings and coronagraph imagery do not currently suggest that these are significant regions at this time, therefore M-class flare probabilities are lowered slightly into Day 3 (16 Sep).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Solar Radiation Storms - (High Energy Protons):

High energy proton flux at GOES-18 is expected to persist at background levels, but with a slight chance of rising in response to any notable flares. The best candidate is currently Ex-AR3811 which has rotated over the southwest limb in the past couple of days. This region has been responsible for multiple M-class flares including an M5.4 observed at 13/0656 UTC. This region will gradually lose its flaring potential as it moves further away from the southwest limb, which could take another day or two.

Radiation Storms	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	15	15	10	10
Very Active	$\geq \text{S3}$ *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)						

High Energy Electrons Event ($\geq 2\text{MeV}$):

The high energy electron flux briefly rose to elevated levels, demonstrating that some charging occurred after the geomagnetic storming that took place on 12 Sep. However, with two further CME arrivals anticipated - first one on Day 1 (14 Sep) and the second one on Day 3 (16 Sep) - plus the potential onset of the high speed stream of CH68 and CH69 on Days 2 & 3 (15 & 16 Sep), any rise is expected to be brief and the high energy flux most likely to stay close to Background levels.

The associated 24-hour fluence is expected to remain below the Active level. The latest MOSWOC REFM output is currently showing a rise, however this is misleading as it isn't taking into account any CME impacts or possible coronal hole interactions.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	5	5
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: GOES-16 $>2\text{MeV}$ Electron Flux (above) and MOSWOC REFM output with recurrence (below)

